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ABSTRACT

This paper presents a study designed to determine if groups of concrete and formal operational children can be identified through the technique of cluster analysis, using a battery of Piagetian tasks. A Total of 64 subjects, 8 boys and 8 girls from each of the second, fourth, sixth, and eighth grade levels, were selected from a public elementary and middle school in suburban upstate New York. Subjects were given five concrete tasks, representing each of the logical groupings studied extensively by Piaget and Irhelder: (1) primary addition of classes (class inclusion), (2) secondary addition of classes, (3) multiplication of classes, (4) asymmetrical addition of relations (seriation), and (5) multiplication of relations. Five formal tasks, representing the integrated group and lattice, were also given: (1) flexibility of rods, (2) oscillation of a pendulum, (3) equilibrium in the balance, (4) hauling weight on an inclined plane, and (5) projection of shadows. It was tentatively concluded that cluster analysis, using these Piagetian tasks, is an effective way to identify concrete and formal operational children. Results suggest that it is possible to form groups of children which are relatively homogeneous, from a Piagetian point of view. (CS)

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Identifying Concrete and Formal Operational Children[1]

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The concept of qualitative differences in development has generated a growing interest in educational planning and evaluation based on a Piagetian model. Previous efforts to examine developmental qualitative differences have focused on the tasks themselves (Berzonsky, 1971; Lee, 1971). That is, are tasks requiring formal operations qualitatively different from tasks requiring concrete operations? For the purposes of educational planning, however, children rather than tasks are the focus of attention. That is, can individual children be identified as primarily concrete or formal operational, on the basis of their performance on Piagetian tasks? It is assumed that such an identification would facilitate the educational process. For example, it follows that children at qualitatively different levels of development would require qualitatively different approaches to a given subject matter. While this assumption has yet to be verified, the terms "concrete operational" and "formal operational" have at least the potential for being more meaningful than traditional educational labels, because of their basis in a comprehensive psychological model which emphasizes constant progress and development.

It is necessary to identify children as primarily concrete or formal operational, both to test the educational usefulness of this approach and, if it is supported, to adopt the technique for practical use. Given more than one concrete and/or formal task, however, such an identification is difficult,

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because of the variability in performance both within and across children. Theoretically "perfect" patterns (i.e. pass all concrete tasks, fail all formal tasks) are seldom seen. To some extent this variability is meaningful within the Piagetian model, in terms of horizontal decalage. Thus a child might pass only a few of several concrete operational tasks because of differences in the content of the tasks (Inhelder & Piaget, 1964). Similarly with formal tasks, a child may be more adept in some areas than in others (Piaget, 1972). Nevertheless, the potential educational usefulness of the technique can be evaluated only if relatively homogeneous groups of children, identifiable as "concrete operational" or "formal operational", can be obtained. Often, such groups have been established on the basis of only one task, or on the basis of some quantitative index (Goldschmidt and Bentlar, 1968) which loses the qualitative distinction so basic to Piagetian theory. Baker (1972), however, has described the usefulness of cluster analysis for generating homogeneous groups of children on the basis of several variables.

The purpose of this study was to determine if groups of concrete and formal operational children could be identified through the technique of cluster analysis, using a battery of Piagetian tasks. The data upon which this study is based were taken from Docherty (1974).

METHOD

Subjects

A total of 64 subjects, eight boys and eight girls from each of the second, fourth, sixth, and eighth grade levels, were selected from a public elementary and middle school in suburban upstate New York. The mean ages at the time of testing was 8 years 3 months (SD = 4 mo.) for the second graders, 10 years 1 month (SD = 3 mo.) for the fourth graders, 12 years (SD = 4 mo.) for the sixth graders, and 14 years (SD = 3 mo.) for the eighth graders.

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Piagetian Items

Five concrete and five formal tasks were selected from The Early Growth of Logic in the Child (Inhelder and Piaget, 1964), and The Growth and Logical Thinking from Childhood to Adolescence (Inhelder and Piaget, 1958) respectively. The five concrete tasks were selected to represent each of the logical groupings studied extensively by Inhelder and Piaget (1964); 1) primary addition of classes (class inclusion), 2) secondary addition of classes, 3) multiplication of classes, 4) asymetrical addition of relations (seriation), and 5) multiplication of relations. The materials for these tasks were variously colored geometric shapes based on the materials described by Inhelder and Piaget (1964). The five formal tasks were selected to represent the integrated group and lattice; 6) Flexibility of rods, and 7) Oscillation of a pendulum, and the formal operational schemata of proportions; 8) Equilibrium in the balance, 9) Hauling weight on an inclined plane, and 10) Projection of shadows. The materials for these tasks were all patterened as closely as possible after Inhelder and Piaget (1958). The instructions and procedures for the ten tasks were developed in a branching format which was designed to retain some of the probing, clinical nature of Piaget's protocols within a standardized structure.

Analysis

Two raters independently scored each item as 1 or 0 on the basis of a scoring system developed from Inhelder and Piaget (1958, 1964). Phi coefficients were used to obtain interrater reliabilities, which ranged from .86 to 1.00.

The individual item scores for each subject were submitted to a Max Hierarchical Clustering Program (Baker, 1972). Since the cluster analysis program rejected zero variances, two second-grade Ss who had failed all items were omitted from the analysis. In addition, a previous task analysis (Docherty, 1974) indicated that the Projection of shadows task had been designed and scored inappropriately, and this task was omitted from the present analysis.

RESULTS

The "best" partition obtained in the hierarchical cluster analysis, in terms of homogeneity of the groups plus interpretability, included 25 subjects in Group 1 and 37 subjects in Group 2. The probability that the overall hierarchical partition was obtained by chance is approximately $p \leq .001$ (Hubert, 1974).

In order to identify the two groups in Piagetian terms, the percent of subjects in each group passing each of the nine Piagetian tasks were determined; these figures are plotted in Figure 1. Mean ages and standard deviations, plus mean score and standard deviations for all concrete tasks and for all formal tasks in each group are presented in Table 1.

Insert Table 1 and Figure 1 about here

The mean number of concrete items passed by Group 1 was 3.52, and by Group 2 was 3.35. This difference was not statistically significant ($t = .66$, $df = 60$). The mean number of formal tasks passed by Group 1 was 1.72, and by Group 2 was .54. This difference was significant ($t = 3.65$, $df = 60$) with $p \leq .001$. Similarly, the mean age of 12 years 4 months for Group 1 was significantly higher ($t = 3.74$, $df = 60$, $p \leq .001$) than the mean age of 10 years 4 months for Group 2.

DISCUSSION

Groups 1 and 2 did not differ in the mean number of concrete items passed, but Group 1 passed significantly more formal tasks than Group 2. Since Group 2 subjects passed an average of only .54 formal tasks, they can be identified as subjects who are in the stage of concrete operations, while Group 1 consists of formal operational subjects. The difference in the mean ages of the two groups is consistent with this conclusion. Classification of the subjects into these two groups is a "best fit", with the groups being relatively homogeneous and descriptive of the original data.

It can tentatively be concluded that cluster analysis, using these Piagetian tasks, is an effective way to identify concrete and formal operational children. However, there is still a considerable degree of variability within each group. Only further research can determine if identifying children in this manner does actually increase the effectiveness of an educational program. Specifically, do the two groups perform differently on a more classroom-oriented task such as reading, and do they respond differently to a particular type of instruction in that task? Conversely, do subjects within a group perform or respond similarly? Correlational and short-term training studies can suggest an answer to these questions, but only long-term curriculum evaluation can test them adequately.

In summary, the results of this study provide general, indirect, support for the Piagetian model of qualitative differences in development. The results suggest that it is possible to form groups of children which are relatively homogeneous from a Piagetian point of view. The study illustrates the use of cluster analysis as a means of identifying such groups, a task which has in the past been largely arbitrary in terms of the items and criteria used for the grouping process.

Table 1

Mean and standard deviation for age and for all concrete and all formal tasks in Groups 1 and 2

	Group 1 N = 25		Group 2 N = 37	
	mean	standard deviation	mean	standard deviation
Age	148 mo.	20 mo.	124 mo.	26 mo.
Concrete score	3.52	.77	3.35	1.09
Formal score	1.72	1.54	.54	.96

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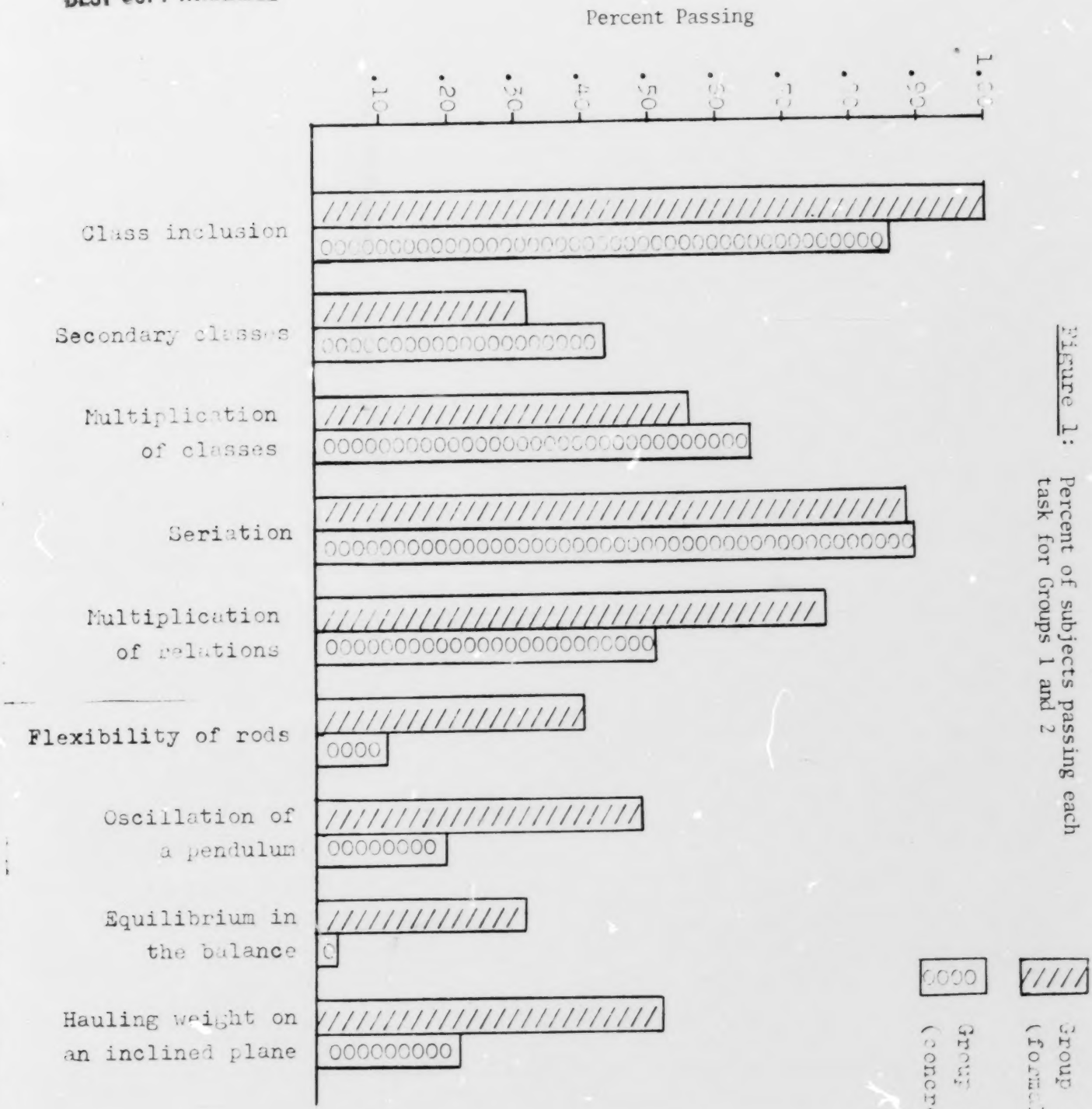

Figure 1: Percent of subjects passing each task for Groups 1 and 2

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